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Expert assistants - productivity to the power of ...!

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Expert Assistants, a type of Expert System, can improve productivity where learning time in a job is longer than a day or two. They can profitably be used to provide a new employee with the knowledge accumulated by their predecessor over a period of months or years. Development time using current shells is cost effective. The objectives of this paper are to give the reader (a) an appreciation of the functionality of an expert assistant, (b) a basic understanding of the potential for productivity enhancement from such a system, and (c) an appreciation of the possible extensions to general training systems.

What is an expert system?

An Expert System is one which captures the knowledge of a human expert as applied to a narrow, specialised domain. The term expert has a slightly different meaning here than in our everyday speech. In this context when we speak of an *expert*, we mean a person who has built up a body of knowledge over time, some of it by education and training and some of it through solving problems as they arise in the course of their job. We do not usually mean someone with a PhD in some obscure segment of Accounting theory.

Expert Systems are based largely on symbolic reasoning. This is what differentiates them from traditional computer programs. By symbolic reasoning, we mean the pattern is not hard and fast. The conditions are not based on numbers but on a structured group of explicit symbols; *words* in our everyday speech. The Expert System has the ability to manipulate these to solve new problems based on previous decisions and their outcomes. As illustrated in Figure 1, Expert Assistants are a subgroup of Expert Systems.

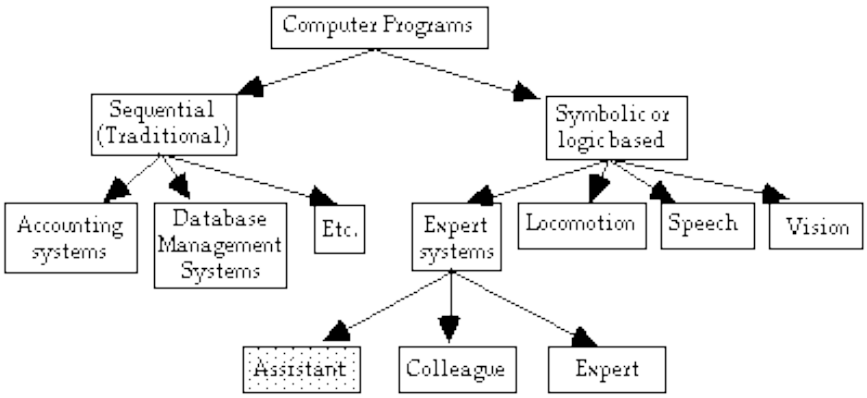

Figure 1. Where the Expert Assistant fits in

Let us look a little more closely at the more familiar type of computer program. It uses sequential programming. The knowledge we have is applied repetitively to our data. Numeric or character data input is manipulated in a manner consistent with what is called *algorithmic* knowledge. An algorithm is a well defined procedure which will solve a problem in a finite number of steps; we know there will be an outcome.

Data processing systems as they currently exist have used this model since the days of the earliest computers. Our Computer Aided Instruction programs, Computer Managed Learning, Accounting Systems and Database Management systems all use this programming model.

The Expert System is also a computer program, but it uses rules of thumb (also called heuristics) applied to narrow, technical knowledge. Input is usually in words (our symbols above) and inference based on logic theory is applied to the set of rules to process that symbolic input. Information comes from many sources as indicated in Figure 2. A readable description of the basic inference mechanisms of these systems is contained in Bahrami (1988) or Walters and Nielsen (l988).

Expert Systems deal particularly well with areas which are not amenable to algorithmic solutions. Those problems are quite common in industry and government today.

There is a third type of system. We'll call it the Creative and Artistic model; it is non-sequential and adaptive. It is based on *common sense* knowledge which we all develop over a period of years of acculturation. It is not possible to build an Expert System using this knowledge with either the current computers or with those we can foresee. It is estimated that

there are 2(10,000,000) items encoded in our basic common sense. The largest and fastest computers available today would require a lifetime or two to process this much knowledge.

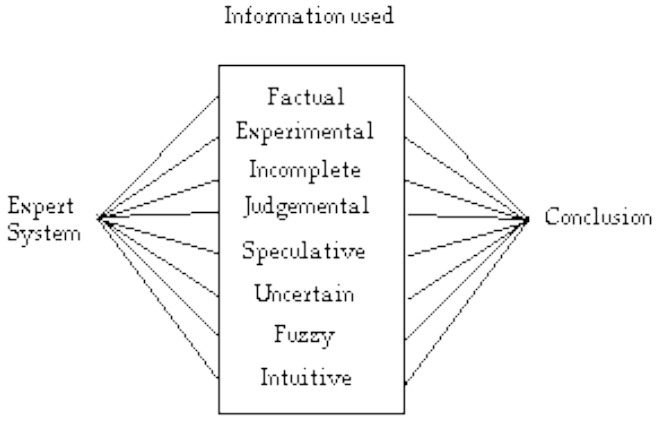

Figure 2. Sources of knowledge for an Expert System
(Adapted from Rausch-Hinden, 1988)

Where is Artificial Intelligence (AI) Now?

In the early 60s, when we were learning the power of computers for repetitive tasks, predictions were that computers would take over human problem solving. Computers have taken over most routine tasks such as bookkeeping, typing and data retrieval; however, they have yet to take over human problem solving. The following statement by Ernest Tello in 1987 still holds.

Nothing has been built as yet that even remotely approaches the functioning of the cerebellum of even the lower amphibians and reptiles.

Those engaged in research on Artificial Intelligence have been particularly interested in making an intelligent pattern recognising machine. Major work has been done in four areas:

- Speech recognition and production, particularly related to Natural (or human) Language,
- Locomotion which has been applied to the area of Robotics,
- Machine Vision which has been applied to the area of Robotics as well as signature and fingerprint recognition, and
- Machine Reasoning which has led to the emergence of Expert Systems. Expert Assistants form one sub-category of Expert Systems.

How do we recognise artificial intelligence?

In 1950 Turing proposed the Imitation Game as a means of determining intelligent behaviour in a machine based program. An interrogator would have keyboard communication with two other persons. The interrogator would not be able to see either party at the other end. The aim of the test is for the interrogator to distinguish between the two persons by asking questions and receiving answers. There is no stipulation that the respondents must answer truthfully. The number of identification errors made by the interrogator was noted. Then one person would be replaced by a machine, and the questions would continue. If the number of errors made by the interrogator was not significantly different, the machine could be deemed intelligent.

This process is illustrated in Figure 3.

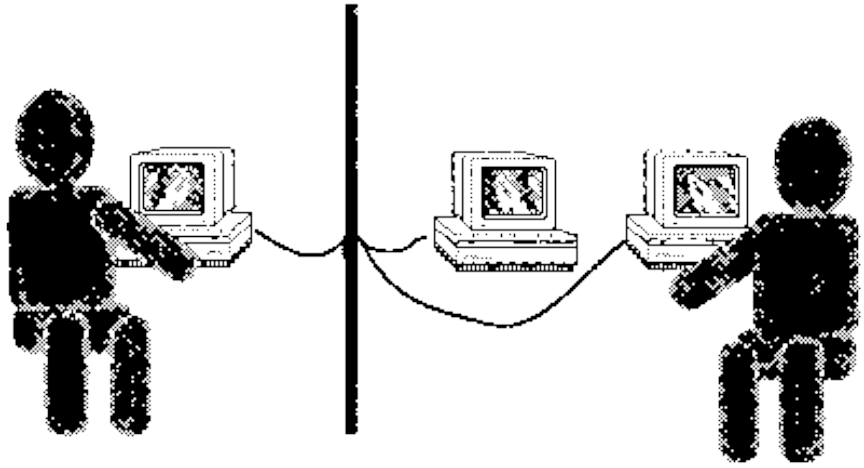

Figure 3. Turing test of artificial intelligence

Expert Systems have been able to meet the Turing test in limited areas, but will consistently fail (as will all sections of artificial intelligence) when only common sense is required to arrive at an answer.

Those portions of common sense knowledge which are important to the area of expertise can be explicitly included in the knowledge base, but we would not include items of common sense which did not directly affect the function of the system. For this reason it is of utmost importance that Expert Systems *know what they don't know*. Most criticisms of expert assistants, expert systems or other areas of artificial intelligence stem from outcomes which seem irrational to the human user.

One of the most famous is the MYCIN expert system, developed to help diagnose diseases of the blood and central nervous system. When presented with a case of a male Caucasian exhibiting high fever and assorted other symptoms, the MYCIN program asked "Is the patient pregnant?" Needless to say, common sense knowledge about the ability of males to be pregnant has since been added to the knowledge base of the MYCIN system.

Why do Expert Systems show promise?

Expert Systems show more immediate promise because they apply what has been learned in Artificial intelligence to practical situations. Since the mid-1980s successful applications of Expert Systems have increased. These contain an explicit, well-organised body of knowledge which includes rules of thumb developed by knowledgeable personnel in the company and a mechanism, called the inference engine, for applying that knowledge to draw new conclusions (see figure 4). Fully developed systems can produce solutions as effectively as their human counterpart within the limits of their knowledge.

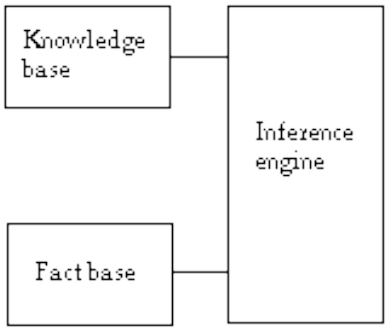

Figure 4. Expert System Architecture

What is knowledge?

The Macquarie Dictionary defines knowledge as "The body of truths or facts accumulated by mankind in the course of time" (1982). Knowledge is the summation of experiences, learning, and rules of thumb which we develop for dealing with the world. The expert deals more effectively with problems where all the facts are not known because of the heuristics they have developed. Their experience provides subjective probabilities of potential causes for the problem as it exhibits itself. Remember, again, the expert we are talking about may be the most senior clerk, or the customer service representative with many years of experience, or a manager who has grown up with the company.

The knowledge is not always locked away in a person's mind. Rather it may be available in written form, but so voluminous that most employees cannot find the answer they require, even if they know it is contained in the reference manuals. This is a situation where an Expert Assistant has been gainfully employed by organisations.

Levels of expert systems: Assistant, colleague and expert

The Assistant level is the most common, and the easiest to develop. The potential gains in productivity from this type of system can be very high. The Assistant can make suggestions for dealing with a problem, help with initial assessments of a problem, assist the employee in collecting appropriate data and suggest the most appropriate person to handle the problem or simply distribute information in an easy to use manner. We will look at this level of Expert System in more detail shortly.

The Colleague level is not as common as the Assistant. This type of Expert System is used to collate knowledge in a field to leverage productivity for an experienced employee. It can also provide help for less experienced employees such as those who work the night or weekend shifts. Colleague level systems often represent improved Assistant systems. The knowledge base is expanded to provide the system with more expertise.

The Expert level is the least common type of expert system. At this level, knowledge has been gathered from multiple sources and the system can be used in place of an expert. Where there are few experts available or the site is remote or harsh, the Expert level system can be justified. It, again, often represents an improved Colleague level system.

Expert Assistants easily solve four types of problems: Productivity bottlenecks; diagnosis of problems; distribution of policy, knowledge or information; and loss of expertise due to employee turnover or retirement.

Examples of problems where an Expert Assistant may help

Productivity

Bottlenecks result where there is only one or a few experienced personnel who spend much of their time helping others rather than applying their expertise to future planning or higher level tasks. An Expert Assistant can reduce the demands on their time as well as raising the knowledge level of the junior employees.

Productivity on night or weekend shifts of a process line is often lower and more uneven than in the day time. Due to seniority, those on the night shift are often less experienced. An Expert Assistant can be used to make expertise more widely available. Mt. Isa Mining has a prototype smelting

process control system which was developed by Cameron Russel of JK Tech. (Russel, 1990)

Personal Loans Assistant was developed at a New South Wales Bank. These loans account for a high proportion of the Bank's customer borrowings. A few loans officers were identified as experts in the personal loans area, and one served as the Expert for the system. (Zawa, 1988)

American Express Authorizer's Assistant provides an automated authorisation service to merchants who accept American Express charge cards. (Briefly described in Tello, 1987).

Australian Bureau of Statistics Seasonal Trend Analyser was developed as a joint project by the ABS and Fujitsu. It was a staged development with the prototype discussed at the 1988 conference on Application of Expert Systems in Sydney (Cox, et al., 1988). It is now in use in Canberra.

Diagnosis of problems

Many diagnostic systems have been implemented as Expert Systems. The help desk of a computer facility lends itself to implementation as an Expert Assistant. Relevant facts can be gathered about the problem by clerical staff and the system can recommend the person most able to cope with that type of problem. Routinely occurring problems can have solutions suggested by the Expert Assistant.

Distribution of policy, knowledge or information

With an Expert Assistant, all users in an organisation can have access to the knowledge. Moreover, the knowledge will be made available in more than one location at a time, and when and where needed.

Manuals of policy, procedures or regulations are often daunting to many employees. As the information becomes more complex, there is an increased probability of incorrect information being given to clients because the information is so difficult or time consuming to locate. These documents are easily represented as a knowledge base. Having the knowledge captured in a central location improves the ease and speed with which these manuals can be updated.

Combining a *Hypertext* interface with an Expert Assistant has special advantages here. Hypertext allows the non-linear connection of text and ideas, a very intuitive and powerful interface technology. Microsoft has published the manuals for their new operating system, OS/2 on a CD ROM disk to facilitate its use. The PC Assistant (Cifuentes, 1989) demonstrates a smaller scale implementation.

Some systems have many manuals and the overlap between them is also significant. An update to one manual may require changes to a dozen others. McDonnell-Douglas would have needed 3.6 tonnes of documents for their newest fighter aircraft. They chose to supply 10 CD-ROM disks with electronic searching and extensive cross references as a better and more usable alternative.

Loss of expertise from employee turnover or retirement

Long serving employees take expertise from the company when they retire. Developing an Expert System can retain this expertise which would otherwise be lost.

An inhospitable location makes turnover endemic. Some companies have a policy of regularly cycling staff through remote locations. An Expert System can be used to standardise productivity and knowledge transfer at the site. The QUT Staff Orientation prototype (Birtwell, 1990) is designed to help with turnover.

Effectiveness of expert systems shells compared to AI languages

Initially, all work in Artificial Intelligence was programmed in either LISP or Prolog. These are programming languages which are designed for manipulation of symbols and incorporate theoretical logic constructs. Developing your first Assistant in either of these languages would be uneconomic. The result also would likely be unacceptable to the employees as substantial effort is required to provide an acceptable user interface in these languages, particularly when compared to modern shells.

In the past two to three years, we have seen many Expert Systems Shells brought onto the market. An Expert System includes the inference engine to interpret the rules and facts and the user interface, but the knowledge about your problem will be missing. We will discuss the desirable characteristics of a shell later.

Using a good shell is analogous to the difference between a modern car and a Model T, or a modern automatic washing machine compared to the old "copper". The shells are not equally capable, but realistic and well defined goals will allow you to reject those unsuitable and find a shell which can be used for your initial foray.

Why can't expert systems be bought off the shelf?

Cultural and regulatory differences usually mean expert systems developed elsewhere will be unsuited to your organisation. Examples of

this problem include an Awards Information Assistant, developed in the UK. The pertinent regulations, while similar to Australia's, are not the same. The outcomes are incorrect for many Australian conditions. Another example is a Stock Broker Expert Assistant developed in the US. In this case, the terminology used is a major problem.

Even within Sydney, corporate culture differences make expert systems difficult to transfer. Just think of two banks. They both make personal loans, but the criteria used may vary widely. If relevant form numbers are referenced, the problem is compounded.

In professional areas, however, cooperative efforts on the part of national associations are bringing assistant and colleague systems on line. At a recent conference, Hadgraft and Wigan (1990) described work being done to make the publication, *Australian Rainfall and Runoff*, more helpful to professional civil engineers.

Picking an Expert Assistant project

Pick a winner. It must be solvable, feasible and beneficial. Remember, doing something faster is not as profitable as doing something smarter. This has already been shown in the traditional computer based systems. In the 1960s, computer systems mimicked the operations clerical personnel performed. Computers simply did those operations faster and more accurately. Over time, more knowledge and policy was built into the programs. The systems today are moving toward enhancing human productivity rather than just doing the same thing faster.

This is particularly true with Expert Assistants. We want to eliminate the bottlenecks in the organisation and improve overall productivity. We can enhance the performance of both the expert and their subordinate by making information and decision rules more widely available.

To determine whether you have a winner, look at the resources available. Are there manuals covering at least a portion of the problem? Is there a willing expert? Is she or he articulate? Will you have management support? Who will be your key team members and what experience do they have?

Set measurable goals. If we haven't set the goals, how do we know when we get there? Measurements can be in terms of decreased demands on the expert's time, increased productivity in the work unit, improved knowledge about the job throughout the work unit, timely availability of induction training for new employees rather than having to wait for the next course, and so on.

Start small. Prove it will work on a part of the problem. This has many benefits. Your team develops experience in the techniques, better focus can be maintained and interface techniques can be tested with the prototype. Additionally, visible results are available sooner and organisational support is enhanced. However, be prepared to throw the prototype away. It is common for the first approach to the problem to be sub-optimal. The techniques learned and problems solved can be put to use in the new version, but don't be afraid to start over. Renovating a poor approach will be more costly and less effective in the long run.

Is it Solvable using expert systems technology?

Expert Systems are useful where the problem mainly requires reasoning. They do not perform well where the problem requires uses of the senses such as smell, taste, touch, vision, or hearing or where a lot of common sense is needed.

If the Expert acquired their competence by solving many problems in this area and a few people with specialised knowledge spend time helping others solve the problem, it is amenable to this technology.

Will it be Feasible as an expert system?

Is the Expert available, willing to take part in the project and articulate? Is there a single expert? If not, is there general agreement among of a group of experts or can one of the group resolve conflicting opinions?

Are the organisational resources adequate? You will need to develop the system. You will also require access to the expert in reasonable (say 1 hour) time chunks.

Are the ultimate users willing and committed to using the system you develop? They should be consulted early to determine their perceived problem areas and how such a system could help. As the prototype is developed, involving them in the testing and incorporating their constructive criticism will improve their commitment.

Is the knowledge readily available or will it all have to come from the Expert? Here it is important to recognise that the way the job actually gets done and the criteria on which the decisions are actually made may differ from written procedures or from the training the company provides. If the knowledge must all come from the Expert, the demands on their time may obstruct the project and make it infeasible.

Are the facts relatively certain? Are there discrepancies in how they are applied? Can the problem be subdivided into smaller problems to allow you to start small?

Can the Expert solve the problem in 3 minutes to 3 hours? For the Assistant level, the 3 to 10 minute problem is the best. Where the problem

requires longer, an Assistant can be useful if a large proportion of the time is spent in gathering data.

Is someone available who has experience with this technology? This may need to be a person from another section of the organisation or an outside consultant. This person can flatten the learning curve for the internal team. For someone with reasonable skills in computing, there are good Shells on the market which can allow the prototype to be developed in less than a month, even without external resources.

Will an Expert System be beneficial?

Are tangible monetary benefits likely to accrue to organisation? Can the system address a significant operational or strategic objective? Expert Assistants can apply both of these benefits.

Would the lack of an Expert System expose the organisation to significant problems or threats? This is not usually appropriate for a simple Expert Assistant. However, experience gained in the development of the Assistant can lead to better definition of a system to address this problem.

Selecting an appropriate shell

All shells are not alike. Some will lend themselves best to diagnostic problems where others such as KnowledgePro® will be very well suited to information distribution. Some, such as VP-Expert™, are useful for learning about Expert Systems while others such as Personal Consultant™ can be used to develop a system through all three levels - Assistant, Colleague and Expert.

- Does the Shell run on hardware already in the organisation? Previously, Expert Systems were only available on purpose built machines. This is no longer the case. Hardware platforms suitable for Expert Assistants include the IBM PC® and PS/2® and compatibles, the Macintosh® and the Unix operating system. Some are also available for mainframes.
- Can a user learn the Shell in less than one week? Many of the Shells which have come on the market in the past two years provide on-line tutorials, on-line help and improved manuals to shorten the learning time.
- Does the Shell's user interface have graphics presentation capabilities? Can the interface be customised to your needs? Does the interface support Hypertext linkages? This is an important consideration for the Assistant. The final system needs to provide an intuitive interface. Hypertext linkages are particularly effective for knowledge distribution and embedded training systems.
- Will the Shell design and vendor-provided examples allow development of demonstration systems in less than one month?

Novices have been able to make use of an analogous model provided by the vendor as a basis for quickly developing a prototype system.
- What additional new technology is required to gain the functionality of the Expert Assistant?
- Can the Shell connect to databases and spreadsheets and other software currently in use in the organisation? This facility broadens the scope of applications and can dramatically decrease the number of rules needed in the knowledge base.
- How effective are the knowledge base editors and knowledge acquisition tools? Productivity will be enhanced if these two elements have been designed to facilitate the knowledge gathering process.
- Does the Shell integrate multiple, proven technology paradigms such as alternative search strategies, confidence factors, frames, multimedia input?
- Can software written in programming languages already used in the organisation be linked with the Shell? This is particularly useful when extending the Assistant. Where special requirements are identified which are not catered for in the Shell, these may be handled by routines written in the programming languages already used by the organisation.

Shells that don't supply file access, code procedures or frames are like trying to write a Data Processing System with only working storage. Further guidance on choosing an appropriate shell can be found in Oxman (1989), Rausch-Hinden (1988), Nisenfeld (1988) or Harmon (1988).

Conclusion

We have briefly explored the potential of Expert Assistants and distinguished them from the larger class of Expert Systems. The availability of better shells has dramatically decreased the cost of development. As the Expert Assistant can be used in many different locations, project paybacks are healthy. Improved user interfaces, including the capabilities of hypertext linkages have also augmented their capabilities and made the them more widely acceptable to users. The Expert Assistant can truly create powerful increases in productivity!

Demonstrations of Expert Assistants

KnowledgePro® is a Knowledge Processor shell which combines the capabilities of Hypertext with a knowledge based shell. This shell runs on IBM and compatible computers. The two examples shown at the Conference are indicative of some of the uses which can be made of the product.

KnowledgePro® is now available for Microsoft® Windows™ version 3 and supports laserdisc video in addition to the capabilities demonstrated

at the Conference. KnowledgePro is a product of Knowledge Garden in the US. For further information, or to arrange to see the demonstrations, please contact the author.

PC Assistant (Cifuentes, 1989)
This product was developed for use by persons new to personal computing. It allows them the opportunity to explore concepts in a non-linear manner and guides them to the desired information. It makes use of the graphic capabilities as well as the hypertext features.

QUT Staff Orientation Assistant (Birtwell 1990)
This prototype was developed for the Personnel section at QUT. It is a prototype, but has demonstrated the feasibility of all the features which are planned for the working Staff Orientation Assistant. Three additional campuses were added to the QUT just as the prototype was completed. The final product will include all campuses.

Trademarks
IBM and PS/2 are registered trademarks of International Business Machines Corporation.
KnowledgePro is a registered trademark of Knowledge Garden Inc.
Macintosh is a registered trademark of Apple Computer, Inc.
Microsoft is a registered trademark and Windows is a trademark of Microsoft Corporation.
Personal Consultant is a trademark of Texas Instruments, Inc.
VP-Expert is a trademark of Paperback Software International.

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Appendix: Some useful guidelines for selecting a first project

A. Conditions which indicate a problem AMENABLE to an Expert System solution:

1. Human experts are being lost through retirement or turnover. The competence of relevant experts was developed by solving many problems in this area.
2. There is a shortage of human experts. Few experts are available and have highly sought after skills or the Experts spend a lot of time helping others with problem solutions.
3. Experts are needed in many locations. (Branches, plants, etc.)
4. Experts are working in hostile environments. (e.g. oil rigs, desert pipelines, etc.)
5. Significant operational or strategic benefits would accrue to the organisation such as a competitive edge, better customer service, increased product quality and so forth.

Remember, the Expert may not necessarily be highly placed but will represent a bottleneck situation.

B. Conditions necessary for selecting an appropriate problem domain:

1. Practical values are expected. Common sense or Blue sky problems are both inappropriate.
2. Heuristics are required for good solutions
   Good may be measured by:
   time it takes to solve the problem
   quality of solution
   cost of solution
   feasibility of solution
   Algorithmic solutions can use the normal programming route. Training is usually better unless turnovers make training uneconomic or appropriately qualified persons are scarce. Problems solved by senses are not appropriate for knowledge based solutions.
3. High return on investment is expected. Expert System will require significant investment. The first system chosen should be a clear financial winner. Expert Assistants are a good first step due to their much lower cost and potential for high visibility.
4. The Expert can solve the problem alone. If many experts are required, is there general agreement among them or one who has final authority? Too many experts spoil the system when they cannot agree.

B. Conditions necessary for possible problem domains:

1. Human experts exist in the domain area. If not, where will you get the knowledge for your knowledge base?
   That Expert must
   - have time to invest in the project;
   - be willing to cooperate in developing the Knowledge base;
   - be able to articulate his knowledge.

1a. The basic knowledge is available: e.g. in procedural manuals, text books, documentation of solved problems. This part is particularly important for the Expert Assistant project as much of the knowledge can be collected from these sources, requiring much less of the Expert's time.

2. Problem solution does not rely on a wide range of common sense. Remember $2^{10,000,000}$ items are estimated to be captured in our common sense.

3. The solution can be explained verbally. You need to explain them to the users.

4. The expert can solve problems of this type within a specified time limit. If it is about 3 minutes it is probably better to train your employees. If it is more than 3 hours, it will be a very large project and definitely not just an Assistant. Be careful that the project is not oversold vis a vis its time and cost.

5. The organisation is willing to commit adequate resources to the project. Management support is the most important. It will also require people, money, time, hardware and software.

6. The end users are willing and committed to using it. Problems to avoid include:
   - fear of redundancy
   - fear of technology
   - office politics
   - union conflict

7. The facts to be dealt with are certain. Expert Systems can deal with uncertainty, but the system will be more difficult to build. This complication is best left to at least the Colleague level system. At the Assistant level, deal mainly with identifiable facts.

8. The problem can be sub-divided into smaller problems. This is very useful as the development can be staged. One small section or a broad

overview of capabilities can be developed to improve estimates of the final time and cost of the system. This also allows the eventual users to try out the prototype and become involved in improvements to the design.

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